

COMPONENT INTERCONNECT APPARATUS

Invented by

**Phillip J. Edwards**

a resident of  
6721 Positano Lane  
San Jose, California 95138

and

**Joseph John Vandenberg**

a resident of  
415 North Lark Ellen Avenue  
West Covina, California 91791

both citizens of  
the United States

1                   COMPONENT INTERCONNECT APPARATUS

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3                   CROSS-REFERENCE TO RELATED APPLICATION

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5               This application claims the benefit of provisional  
6 application serial number 60/275,002, filed 12 March 2001.

7

8                   FIELD OF THE INVENTION

9

10               This invention relates to components used in  
11 optoelectric modules and the like.

12

13               More particularly, the present invention relates to  
14 interconnect apparatus between various components used in  
15 such modules and other electronic equipment.

16

17

18                   BACKGROUND OF THE INVENTION

19

20               In optical-to-electrical and electrical-to-optical  
21 (hereinafter "optoelectric") modules used in the various  
22 communications fields, one of the most difficult problems  
23 that must be solved is the efficient transmission of light  
24 between a light generating device and an optical fiber or,  
25 alternatively, the transmission of light from the optical  
26 fiber to a light receiving device. Providing this efficient  
27 transmission requires very precise assembly procedures.

1 Here it will be understood by those skilled in the art that  
2 the term "light" is a generic term which includes any  
3 electromagnetic radiation that can be modulated and  
4 transmitted by optical fibers or other optical transmission  
5 lines.

6

7 Much of the optoelectric module fabrication difficulty  
8 and expense is due to mounting difficulties of optical  
9 components, such as lasers, light emitting diodes,  
10 photodiodes, etc. Generally, there are two types of lasers  
11 that are used in optoelectric modules, edge emitting lasers  
12 and surface emitting lasers. Edge emitting lasers emit  
13 light in a path parallel to the mounting surface while  
14 surface emitting lasers emit light perpendicular to the  
15 mounting surface. The light from either of the lasers must  
16 then be directed into an optical fiber for transmission to a  
17 remotely located light receiver (i.e., a photodiode or the  
18 like). Lens systems are used at both ends of the optical  
19 fiber to direct light from a light generating component into  
20 the optical fiber and to direct light from the optical fiber  
21 onto a light sensing component. The apparatus used to mount  
22 the optical components and the lens systems can have a  
23 substantial effect on the construction of the optical  
24 systems and the assembly procedures for the optical systems.  
25 Also, the mounting structure for the optical components and  
26 the lens system must be very rugged and stable so that  
27 alignment is not disturbed by use or temperature changes.

1        It would be highly advantageous, therefore, to remedy  
2    the foregoing and other deficiencies inherent in the prior  
3    art.

4

5        Accordingly, it is an object the present invention to  
6    provide new and improved optical component mounting and  
7    interconnect apparatus.

8

9        Another object of the present invention is to provide  
10   new and improved optical component mounting and interconnect  
11   apparatus which is rugged and stable.

12

13        And another object of the present invention is to  
14   provide new and improved optical component mounting and  
15   interconnect apparatus which improve the fabrication  
16   efficiency and manufacturing capabilities of optoelectric  
17   modules.

18

19        Still another object of the present invention is to  
20   provide new and improved optical component mounting and  
21   interconnect apparatus which allows the use of a variety of  
22   optical components and component materials.

23

24        Another object of the present invention is to provide  
25   new and improved component mounting and interconnect  
26   apparatus which is capable of communicating high frequencies  
27   between components and connecting circuits.

1 Still another object of the present invention is to  
2 provide new and improved component mounting and interconnect  
3 apparatus which is designed to reduce outside interference  
4 with the desired signal.

5

6 Another object of the present invention is to provide  
7 new and improved component mounting and interconnect  
8 apparatus that can have a fixed impedance which, upon  
9 matching to components or circuitry, further increase the  
10 efficiency of the coupling.

## SUMMARY OF THE INVENTION

Briefly, to achieve the desired objects of the present invention in accordance with a preferred embodiment thereof, provided is optical component mounting and interconnect apparatus including a base formed of at least one layer of insulating material. At least one via extends through the base. An optical component mounted on the first major surface of the base has an electrical terminal coupled to one end of the via and a flex circuit is affixed to the second major surface of the base with an electrical connection to the opposite end of the via.

13           In a more specific embodiment, the component mounting  
14        and interconnect apparatus includes a base formed of at  
15        least one layer of insulating material defining first and  
16        second opposed major surfaces with a plurality of vias  
17        extending from the first major surface to the second major  
18        surface. The plurality of vias include a signal via and two  
19        spaced apart ground vias parallel with and on opposite sides  
20        of the signal via, whereby the signal via and two ground  
21        vias form a transmission line. An electrical component is  
22        mounted on the first major surface of the base with an  
23        electrical terminal affixed to one end of the signal via and  
24        a circuit is affixed to the second major surface of the base  
25        with an electrical connection to the opposite end of the  
26

1 signal via, whereby the transmission line communicates  
2 signals between the component and the circuit.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further and more specific objects and advantages of the invention will become readily apparent to one skilled in the art from the following detailed description of a preferred embodiment thereof, taken in conjunction with the drawings in which:

FIG. 1 is a sectional view of a simplified optoelectric cell in accordance with the present invention;

FIG. 2 is an enlarged sectional view of the electric package of the optical/electrical module of 1; and

FIG. 3 is a simplified sectional view of a transmission connection to the optoelectric package.

1                   DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

2

3                 The present invention provides new and improved

4         mounting features for telecommunication and data

5         communication apparatus and the like and in particular for

6         optoelectric modules. Turning to FIG. 1, a sectional view

7         is illustrated of a simplified optoelectric module 10 in

8         accordance with the present invention. As stated above, the

9         term "optoelectric" is used herein to denote the fact that

10        module 10 can be either an optical-to-electrical or

11        electrical-to-optical module.

12

13                It will be understood by those skilled in the art that

14        modules of the type discussed herein generally include a

15        pair of channels, one of which receives electrical signals,

16        converts the electrical signals to optical (light) beams by

17        way of a laser or the like and introduces them into one end

18        of an optical fiber, which then transmits the modulated

19        optical beams to external apparatus. The second channel of

20        the module receives modulated optical beams from an optical

21        fiber connected to the external apparatus, conveys the

22        modulated optical beams to a photo diode or the like, which

23        converts them to electrical signals. In the following

24        description, the apparatus and methods can generally be used

25        in either of the channels but, since the optical portions of

26        the two channels are substantially similar, only one channel

27        will be discussed with the understanding that the

1 description applies equally to both channels. Also,  
2 throughout this disclosure, unless a specific component is  
3 described, the term "laser" is intended to denote any light  
4 source including, for example, a laser, a light emitting  
5 diode, the end of a light communicating optical fiber, etc.  
6 and light receiving structures are intended to include any  
7 one of a photo-diode, a pin diode, an end of a light  
8 communicating optical fiber, etc.

9

10       Module 10 of FIG. 1 includes a receptacle element or  
11 assembly 11 and an optoelectric element or package 12  
12 aligned and affixed together, as will be disclosed in more  
13 detail below. Receptacle assembly 11 is designed to receive  
14 an optical fiber 14 in communication therewith, in a manner  
15 that will become clear presently. In the preferred  
16 embodiment, optical fiber 14 is a single mode fiber (the use  
17 of which is one of the major advantages of the present  
18 invention) including a glass core 15 and a cladding layer  
19 16.      Receptacle assembly 11 includes an elongated  
20 cylindrical ferrule 20 defining a fiber receiving opening 21  
21 at one end and a mounting flange 22 at the opposite end.

22

23       Progressing from the end of module 10 which defines  
24 opening 21 toward the end defining flange 22, ferrule 20 has  
25 two radially outwardly directed steps 32 and 33. Step 32  
26 provides a surface or stop for the mounting of an optical  
27 spacer 35 and step 33 provides a surface or a stop for the

1 positioning of an optical lens assembly 36. In this  
2 preferred embodiment, lens assembly 36 is formed of plastic  
3 and may be, for example, molded to simplify manufacturing of  
4 module 10. It should be understood that the term "plastic"  
5 is used herein as a generic term to describe any non-glass  
6 optical material that operates to transmit optical beams of  
7 interest therethrough and which can be conveniently formed  
8 into lenses and the like. Similarly, the term "glass" is  
9 defined as any material that is substantially temperature  
10 insensitive (i.e., stable throughout the operating  
11 temperature of the module), such as glass, crystalline  
12 material, or semiconductor material (e.g. silicon, oxides,  
13 nitrides, some ceramics, etc.). For example, in most  
14 optical modules used at the present time the optical beams  
15 are generated by a laser that operates in the infra-red band  
16 and any materials that transmit this light, including some  
17 oxides and nitrides, come within this definition.

18

19        Lens assembly 36 defines a central opening for the  
20 transmission of light therethrough which extends from an end  
21 37 to an opposite end 38. A lens 39 is integrally formed in  
22 the central opening a fixed distance from end 37. Lens  
23 assembly 36 is frictionally held in place within ferrule 20  
24 and in this embodiment holds spacer 35 fixedly in place. In  
25 other embodiments, lens assembly 36 may be moveable along  
26 the Z or optical axis a limited distance. Also, lens 39 is  
27 spaced a fixed distance from spacer 35. In this preferred

1 embodiment, optical fiber 14 is inserted into ferrule 20 so  
2 that glass core 15 buts against spacer 35, which  
3 substantially reduces or suppresses return reflections.

4

5 Optoelectric package 12 includes a base 41 comprising  
6 (in this example) a support plate 40 and a mounting plate 42  
7 positioned thereon. One or more spacer rings 43 may be  
8 positioned on plate 42 to provide sufficient distance for  
9 components mounted thereon. In this example a laser 45 is  
10 mounted on the upper surface of mounting plate 42 and  
11 positioned to transmit light generated therein to a lens  
12 block 46. Alternatively, laser 45 could be a photodiode or  
13 the like. Lens block 46 is mounted on mounting plate 42 by  
14 some convenient means, such as outwardly extending ears (not  
15 shown).

16

17 Laser 45 is mounted to one side of the optical axis Z,  
18 defined by optical fiber 14 and lens 39. Lens block 46 is  
19 constructed to define a lens with a curved reflecting  
20 surface designed to direct impinging light, received at an  
21 angle to the Z axis, along the Z axis and to collimate the  
22 impinging light. Additional lenses may be formed, if  
23 desired, in either or both of the inlet surface and the  
24 outlet surface of lens block 46. Lens block 46 can be  
25 molded from plastic or it can be formed to fixedly mount a  
26 glass curved reflecting surface in a fixed position relative

1 to laser 45. A distance d is the distance between laser 45  
2 and the curved reflecting surface of lens block 46.

3

4 A ring 47 is positioned on spacer rings 43 and a cap or  
5 cover 48 is affixed to ring 47. Generally, the entire  
6 assembly, including plate 40, mounting plate 42, spacer  
7 rings 43, ring 47 and cover 48 are fixedly attached together  
8 by some convenient means, such as welding, gluing, etc. so  
9 that laser 45 is enclosed in a hermetically sealed chamber.  
10 However, a hermetic seal is not necessary in many  
11 embodiments in which the laser or photodiode used is either  
12 separately sealed or is not sensitive to atmospheric  
13 conditions.

14

15 A window 50 is sealed in cover 48 so as to be aligned  
16 with lens block 46. Lens block 46 redirects light from  
17 laser 45 at a ninety degree angle out through window 50,  
18 which may include one or more lenses or optical surfaces.  
19 Further, window 50 is affixed to the underside of cover 48  
20 by some convenient means, such as epoxy or other adhesive,  
21 so as to hermetically seal the light transmitting opening  
22 through cover 48. If a hermetic seal is not required,  
23 window 50 can be formed (e.g. molded) from plastic. Lens  
24 block 46 may be molded from plastic for convenience in  
25 manufacturing.

1        Optoelectric package 12 is affixed to receptacle  
2 assembly 11 with flange 22 of ferrule 20 butting against the  
3 upper surface of cover 48. Further, optoelectric package 12  
4 is optically aligned with receptacle assembly 11 so that  
5 light from laser 45 is directed into core 15 of optical  
6 fiber 14. This alignment can be accomplished in different  
7 ways but one reliable method is known as active alignment.  
8        In this process, laser 45 is activated and receptacle  
9 assembly 11 is positioned approximately over optoelectric  
10 package 12. The light in optical fiber 14 is measured and  
11 the alignment is adjusted for maximum light. When maximum  
12 light is measured alignment has been achieved and receptacle  
13 assembly 11 is fixed to optoelectric package 12 by some  
14 convenient means, such as welding or adhesive.

15  
16        Turning now to FIG. 2, an enlarged sectional view of  
17 optoelectric package 12 is illustrated. While optoelectric  
18 package 12 is illustrated with a base 41 including support  
19 plate 40 and mounting plate 42, it will be understood that  
20 base 41 can include any number of layers from one to several  
21 and may be formed of any non-conducting material which is  
22 sufficiently hard to provide the necessary support and  
23 rigidity for maintaining alignment. In this disclosure the  
24 term "base" is intended to be generic for any type of  
25 support, e.g. plastic, layered board, layered or solid  
26 sheets of ceramic, semiconductor substrates, etc. Also, a  
27 flex circuit 60 is shown connected to the lower surface of

1 support plate 40 of package 12. In this embodiment, for the  
2 transmitting module 10, flex circuit 60 couples laser 45 and  
3 a monitor diode 70 (if present) to circuits (e.g. drivers,  
4 amplifiers, etc.) on a printed circuit board, not shown.  
5 Similarly, for a receiving module (not shown), a flex  
6 circuit couples the photodiode to circuits on the printed  
7 circuit board. Electrical connections between flex circuit  
8 60 and the various components in optoelectric package 12 are  
9 made directly through base 41.

10

11         Turning to FIG. 3, specific apparatus for coupling  
12 components (e.g. laser 45) in optoelectric package 12 is  
13 illustrated. In this structure parallel sets of adjacent  
14 through-holes or vias 72, 73, and 74 are provided through  
15 base 41. All three of the vias are plated (but could be  
16 filled with solder or other conductive material in some  
17 embodiments) and the centrally located via 72 is connected  
18 to one terminal of laser 45. Vias 73 and 74 are plated (but  
19 could be filled with solder or other conductive material)  
20 and connected to ground at one or both ends.

21

22         Because of the proximity of the three vias 72, 73, and  
23 74, the signal via 72 with the ground vias 73 and 74 on  
24 either side operate as a transmission line for high  
25 frequencies. Transmission lines of this type are very  
26 efficient for coupling electrical signal between a component  
27 and other circuitry. Further, the ground lines on either

1 side of the signal line prevent any interference with the  
2 signal. Coupling transmission lines of this type can be  
3 used in various other circuits to connect components  
4 together or to other circuits. Further, as a transmission  
5 line the three vias 72, 73, and 74 can have a fixed  
6 impedance which, upon matching to components or circuitry  
7 further increase the efficiency of the coupling.

8

9 It should be noted that the formation of vias in the  
10 base allows the mounting of optical components, e.g., laser  
11 45, directly on the base which substantially improves the  
12 ruggedness of the structure and the stability of the optical  
13 alignment. Further, the size of the vias can be selected to  
14 allow limited movement of the optical components during the  
15 initial positioning and mounting so that manufacturing  
16 tolerances of the base can be eased substantially. Also,  
17 because of the positioning of the optical components  
18 directly on the base, machine assembly (e.g., pick and place  
19 machines) can be more easily adapted to the assembly  
20 process.

21

22 Accordingly, new and improved mounting and interconnect  
23 features are disclosed which substantially reduce time and  
24 effort in assembly and alignment procedures and which  
25 improve the efficiency of optical systems. Thus,  
26 manufacturing tolerances can be substantially reduced,  
27 substantially reducing manufacturing time, labor, and costs.

1 Further, the new and improved mounting and interconnect  
2 features allow the use of a variety of components and  
3 component materials.

4

5 Various changes and modifications to the embodiments  
6 herein chosen for purposes of illustration will readily  
7 occur to those skilled in the art. To the extent that such  
8 modifications and variations do not depart from the spirit  
9 of the invention, they are intended to be included within  
10 the scope thereof which is assessed only by a fair  
11 interpretation of the following claims.

12

13 Having fully described the invention in such clear and  
14 concise terms as to enable those skilled in the art to  
15 understand and practice the same, the invention claimed is: